DYNAMIC SIMULATION OF A PERIODIC 10 K SORPTION CRYOCOOLER

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A transient thermal simulation model has been developed to simulate the dynamic performance of a multiple-stage 10 K sorption cryocooler for spacecraft sensor cooling applications that require periodic quick-cooldown (under 2 minutes), negligible vibration, low power consumption, and long-life (5 to 10 years). The model was specifically designed to represent the Brilliant Eyes Ten-Kelvin Sorption Cryocooler Experiment (BETSCE), but it can be adapted to represent other sorption cryocooler systems as well.

The model simulates the heat transfer, mass transfer and thermodynamic processes in the cryostat and the sorbent beds for the entire refrigeration cycle, including the following:

(1) Charging the hydrogen supply tank to high pressure (> 10 MPa) via sequenced, thermally-powered, sorbent bed resorption.

(2) Cooldown from 60-70 K to below 28 K in 60 to 80 seconds by release of high-pressure hydrogen from the supply tank to the Joule-Thomson (J-T) refrigeration loop, while maintaining the back-pressure below 0,25 MPa with the $LaNi_{4.8}Sn_{0.2}$ fast absorber sorbent bed. The model includes the transient effects of variable hydrogen supply pressure due to expansion and outflow of hydrogen during the cool down operation.

(3) Cooldown from 28 K to < 11 Kin under 30 seconds by evaporative cooling, solidification, and sublimation of liquid hydrogen. This phase is driven by the ZrNi hydride low-pressure sorbent bed, which reduces the pressure from 0.25 MPa and maintains it at under 2 x 10"4 MPa for the required cooling period of 10 to 20 minutes.

The paper describes model limitations and simplifying assumptions, and presents comparisons of cycle performance predictions with ground test data. An important benefit of the model is its ability to predict performance sensitivities to variations of key design and operational parameters. The insights thus obtained are expected to lead to higher efficiencies and lower weights for future designs.

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